Variability of the Boundary Current systems and AMOC at 11°S

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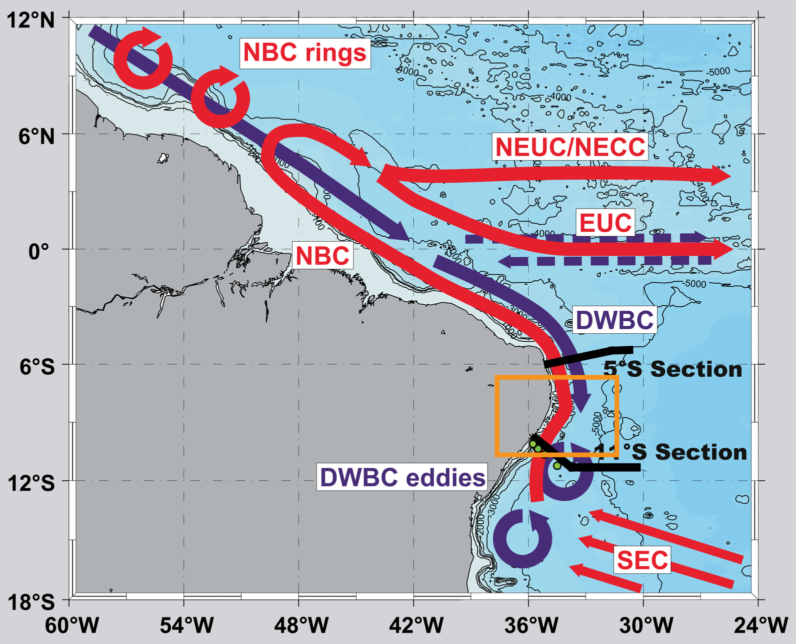

Fig.1: Circulation scheme of the western tropical Atlantic (Dengler et al., 2004). Warm- (Cold) water routes of the AMOC are indicated in red (blue), hydrographic sections in black and mooring positions as green circles.

Introduction

The tropical Atlantic plays an important role for climate variability in the Atlantic region. The western boundary current system serves as a key region, where the variability of the North Brazil Undercurrent (NBUC) and the Deep Western Boundary Current (DWBC) exhibit variations of the AMOC (Fig. 1) and the Subtropical Cells (STCs, Fig. 2).

Measurement program

The boundary current systems at 11°S off the coast of Brazil and Angola are investigated with mooring arrays and ship based observations including direct current as well as hydrographic measurements. Three research cruises in 2013, 2014 and 2015 and the retrieval of the moored observations delivered first insights into the variability of the currents and water mass properties. The observational campaign aims at assessing the variability of the boundary current systems on various time scales from intraseasonal to interannual, whereas at the western boundary even decadal variability is investigated comparing the new data set to similar observations during the period 2000-2004. In addition, bottom pressure sensors are installed on the eastern and western side of the basin at 300m and 500m in order to estimate the interior mid-ocean transport.

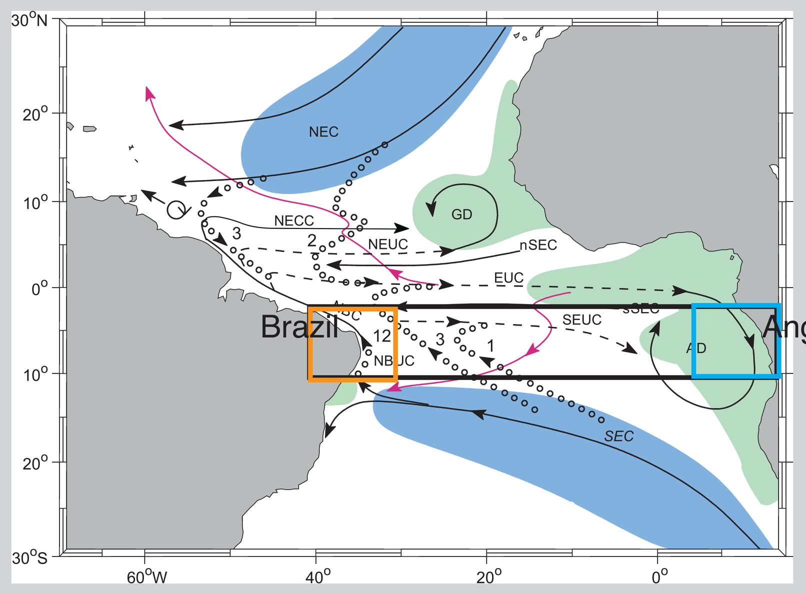

Fig.2: Circulation scheme depicting the main current branches of the Subtropical Cells in the Atlantic (Schott et al., 2004). Subduction areas are shaded in blue, upwelling regions in light green. The numbers represent transport estimates.

Western Boundary Current (WBC) System

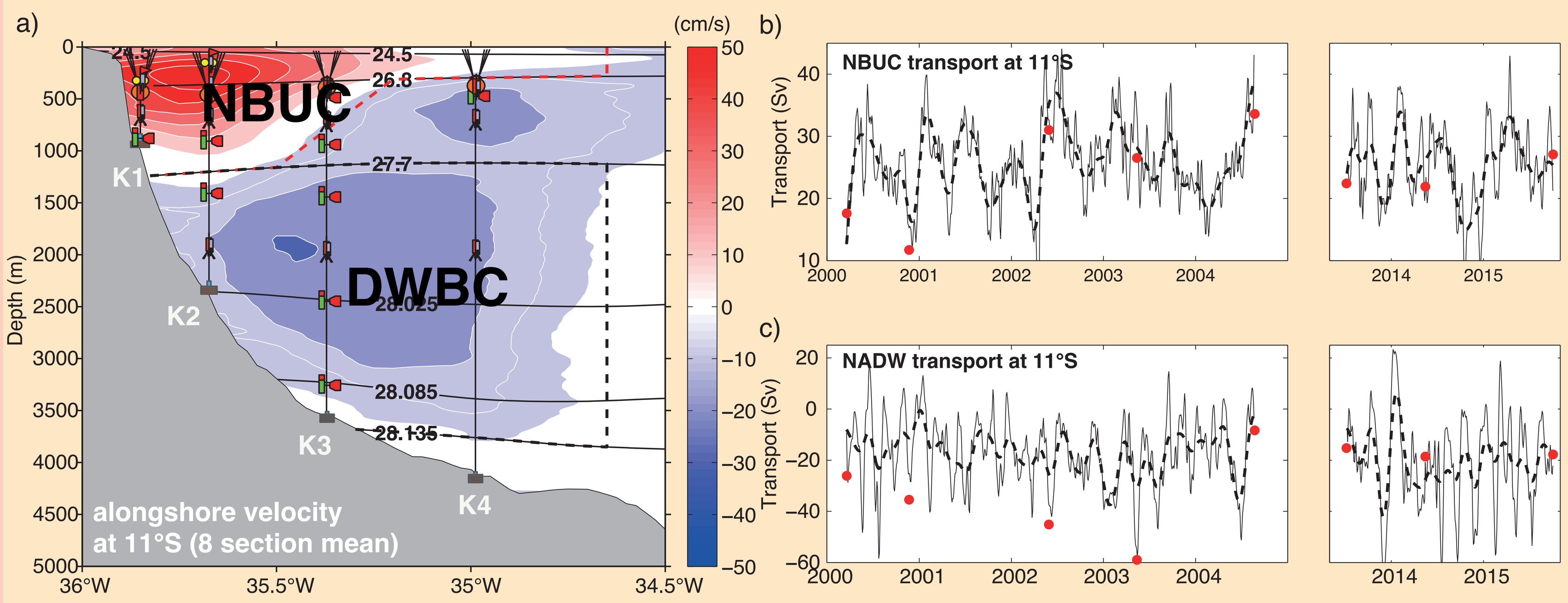

Fig. 3: Average ship section of alongshore velocity off the coast of Brazil with mooring array design (a), and NBUC (b) and DWBC (c) transport time series obtained from morred observations. Red and black dotted lines in a) mark boxes used for transport calculations. Red dots in b) and c) indicate transport estimates from ship sections.

(Sv)	2000-2004	2013-2015
NBUC	25.8±1.2	25.5±1.3
DWBC	-17±1.6	-20.5±2.7

- On intraseasonal timescales the Deep Eddies, which have been shown to accomplish the transport of NADW instead of a laminar flow and were predicted to disappear with a weakening AMOC (Dengler et al. 2004), are still present with similar characteristics (Fig. 1,3).
- On longer timescales the variability of the NBUC and DWBC is reduced compared to intraseasonal timescales.
- On average moored observations do not show significant changes between the two observational periods (see table).
- Interannual NBUC variability as assessed from moored observations between 2000-2004 is consistently found in the output of a forced ocean model (INALT01).
- Decadal variability is similar in INALT01 and geostrophic transport estimates from Zhang et al. (2011).

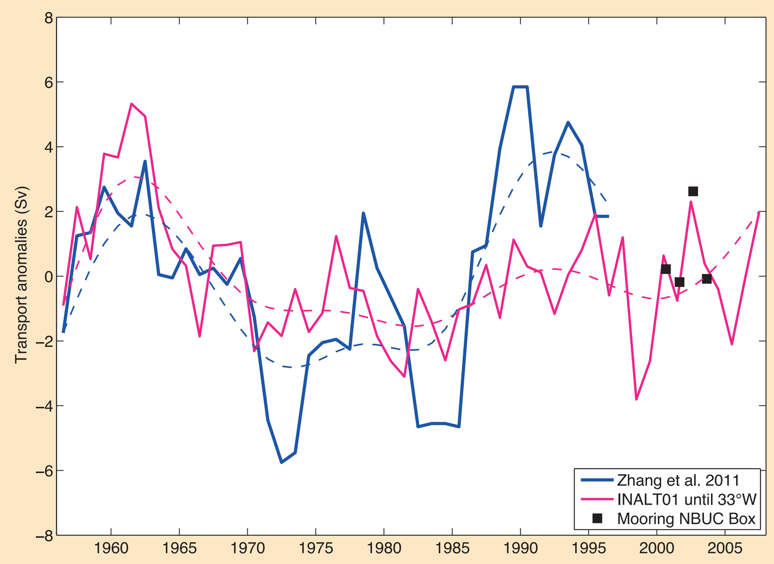

Fig. 4: NBUC transport anomalies, where 15, 16 and 25 Sv were subtracted (INALT01, geostrophic transports and moored observations).

Water mass properties

- The observed decadal salinity increase in the central water range (100-600m) is consistent with previous estimates (Biastoch et al. 2009) as well as the interannual variability of salinity anomalies (Fig. 5a, Kolodziejczyk et al. 2014).
- The inferred vertical structure of salinity and oxygen trends (Fig.5c,d) can be related to changes in water mass formation regions as well as circulation changes in remote regions of the Altanic.

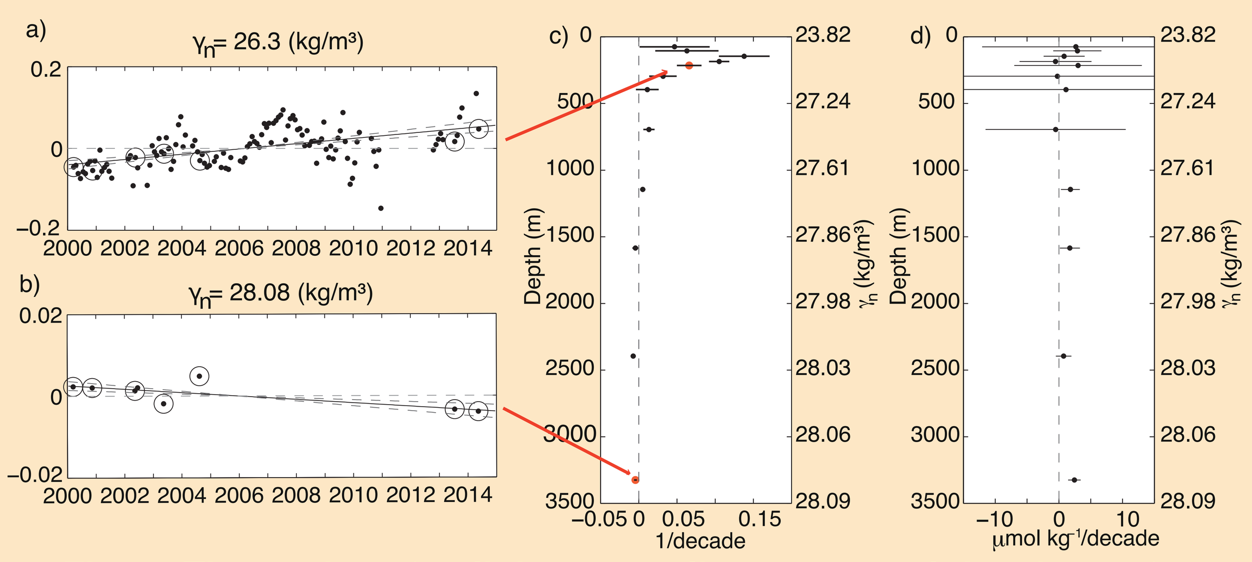

Fig. 5: Timeseries of salinity anomalies on neutral density surfaces (a,b) and the resulting salinity as well as oxygen trends (c,d).

Eastern Boundary Current (EBC) System

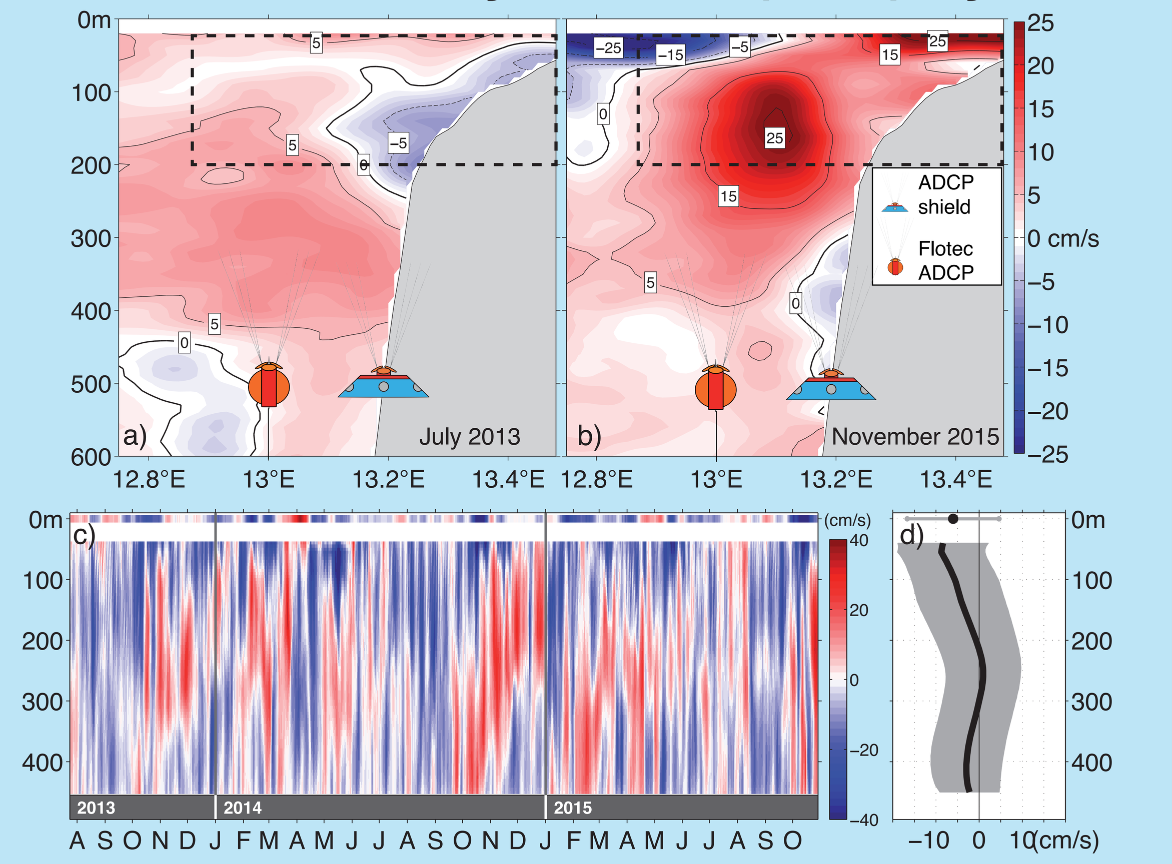

Fig. 6: Alongshore velocity off the coast of Angola obtained during two ship sections with moorings, black dashed box used for transports (a,b). Time series (c) and average (d) of moored alongshore velocity.

- Alongshore velocities are highly variable at the eastern boundary and dominated by alternating periods of southward/northward flow with a duration of several months (Fig. 6a,b,c).
- On average a weak mean southward flow is observed extending to about 200m depth with maximum southward flow of 5-8 cm/s at 50m depth (Fig. 6d).
- Seasonal variability is dominated by 120-day, semi-annual and annual oscillations.
- The Angola Current (AC) transport derived from the combination of moored and shipboard observations shows a mean of -0.32±0.05 Sv (Fig. 7) and its semi-annual cycle is quasi-synchronized with semi-annual coastal Kelvin waves.

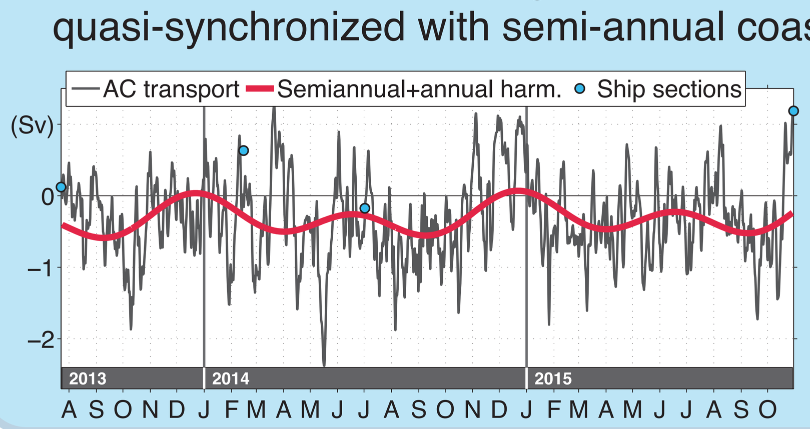

Fig. 7: AC Transport time series. Superposition of semiannual and annual harmonic in red, estimates from ship sections as blue circles.

Future work: AMOC estimate at 11°S

- Construction of a transport time series of the AMOC at 11°S in order to analyze the mean, and seasonal as well as interannual variability:

$$T_{AMOC}(t)=T_{MO}(t)+T_{EK}(t)+T_{WBC}(t)+T_{EBC}(t)$$

- Ekmantransport T_{EK}: Comparison of different wind products and observations
- WBC Transport T_{WBC}: Transport estimates using the moored and shipboard observations as well as a geostrophic approach

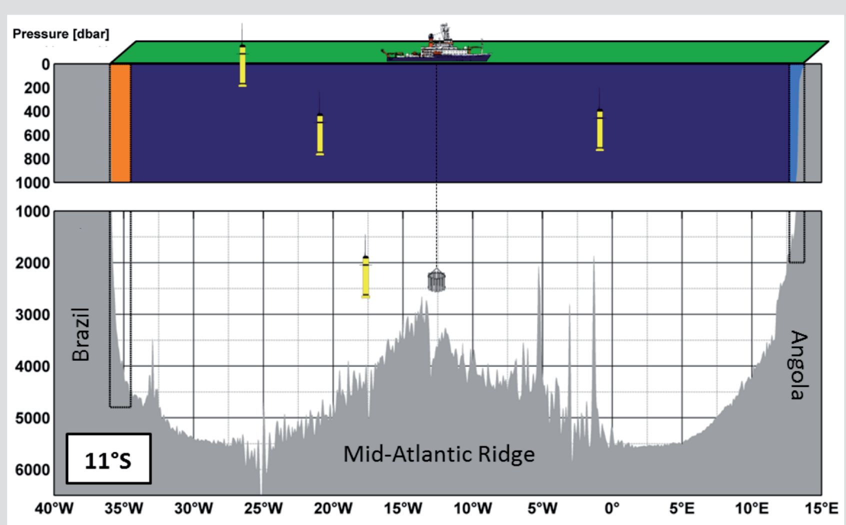

Fig. 8: Section of bathymetry at 11°S with colors depicting the different components of the AMOC

- EBC Transport T_{EBC}: Transport estimates using moored and shipboard observations
- Mid Ocean transport T_{MO}: Determination of an interior geostrophic transport time series for the upper 1000m at 11°S using
  - Sea surface height from satellite altimetry or PIES installed on both sides of the Atlantic basin
  - Geostrophic transports from Argo and ship based hydrography
  - Meridional velocities at 1000m depth from Argo floats

Summary

- **WBCS:** no significant transport changes between 2000-2004 and 2013-2015; DWBC eddies still present; interannual to decadal variability agrees among moored observations, numerical simulations and geostrophic estimates
- **EBCS:** weak southward AC transport; 120-day, semiannual and annual oscillations dominate variability
- **Outlook:** relate assessed variability patterns of the WBCS, EBCS and the AMOC at 11°S to AMOC variablity in remote regions of the Atlantic

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